Hot Springs National Park

Geologic Resources Division
National Park Service
US Department of the Interior

The Geologic Resource Evaluation (GRE) Program provides each of 270 identified natural area National Park Service units with a geologic scoping meeting, a digital geologic map, and a geologic resource evaluation report. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity for discussion of park-specific geologic management issues and, if possible, include a site visit with local experts. The purpose of these meetings is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and potential monitoring and research needs. Outcomes of this scoping process are a scoping summary (this report), a digital geologic map, and a geologic resource evaluation report.

The National Park Service held a GRE scoping meeting for Hot Springs National Park on April 23, 2007 at the park's Ozark Bathhouse facility in Hot Springs, Arkansas followed by a field trip excursion of the area on April 24, 2007. Tim Connors (NPS-GRD) facilitated the discussion of map coverage and Bruce Heise (NPS-GRD) led the discussion regarding geologic processes and features at the park. Participants at the meeting included NPS staff from the park, Geologic Resources Division, Arkansas Geological Survey, U.S. Geological Survey as well as cooperators from Colorado State University (see table 1). This scoping summary highlights the GRE scoping meeting for Hot Springs National Park including the geologic setting, the plan for providing a digital geologic map, a prioritized list of geologic resource management issues, a description of significant geologic features and processes, lists of recommendations and action items, and a record of meeting participants.

Park and Geologic Setting

Hot Springs National Park began as Hot Springs Reservation established on April 20, 1832. This designation is the oldest record of land set aside for preservation by the Federal Government. On March 4, 1921, Hot Springs Reservation became a national park. After numerous boundary changes, the current park covers 5,549.75 acres (Federal: 4,932.78 acres) in Garland County. The park protects 47 geothermal hot springs and 8 historically significant bathhouses as part of a National Historic Landmark District. Forested ridges and valleys of the Ouachita Mountains surround the park. The national park sits within the 7.5-minute Hot Springs North and Hot Springs South quadrangles. Notable ridges in the park include Hot Springs, North, Sugarloaf, Music, and West Mountains. The slopes of these ridges are steep rising from less than 210 m (700 ft) above sea level to more than 425 m (1,400 ft) at Music Mountain over a short distance. Hot Springs Creek runs through the center of the park, whereas Gulpha Creek carves a gorge along the western edge. The geology in this area is structurally and stratigraphically complex. Numerous thrust and reverse faults juxtapose rocks of Ordovician through Mississippian age. Local structures include overturned, plunging anticlines. Dominant geologic units in the area include the Stanley Shale, Hot Springs Sandstone, Arkansas Novaculite, and Bigfork Chert. The geothermal features at the park cluster on the southwest slope of Hot Springs Mountain where geologic structure and bedding conduct water from great depths relatively quickly to the surface with average temperatures of ~62°C (~143°F). This water reacts with the surrounding country rock forming tufa and travertine deposits.

Geologic Mapping for Hot Springs National Park

During the scoping meeting Tim Connors (NPS-GRD) showed some of the main features of the GRE Programs digital geologic maps, which reproduce all aspects of paper maps, including notes, the legend, and cross sections, with the added benefit of GIS compatibility. The NPS GRE Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation set for the GRE Program. Staff members digitize maps or convert digital data to the GRE digital geologic map model using ESRI ArcMap software. Final digital geologic map products include data in geodatabase, shapefile, and coverage format, layer files, FGDC-compliant metadata, and a Windows HelpFile that captures ancillary map data. Completed digital maps are available from the NPS Data Store at http://science.nature.nps.gov/nrdata/.

When possible, the GRE program provides large scale (1:24,000) digital geologic map coverage for each park's area of interest, usually composed of the 7.5-minute quadrangles that contain park lands (figure 1). Maps of this scale (and larger) are useful to resource management because they capture most geologic features of interest and are positionally accurate within 40 feet. The process of selecting maps for management use begins with the identification of existing geologic maps and mapping needs in vicinity of the park. Scoping session participants then select appropriate source maps for the digital geologic data to be derived by GRE staff.

At HOSP, resource management staff identified the following 7.5' quadrangles as being of interest because of the implications on regional recharge: Hot Springs North, Fountain Lake and the northern halves of both Hot Springs South and Lake Catherine. The Arkansas Geological Survey (AGS) has preliminary geologic worksheets for all of these quadrangles, but none are published dedicated geologic quadrangle maps. To assist the NPS with their goal of creating large-scale digital geologic map coverage, the AGS has proposed to refine their mapping of these quadrangles and to assemble them into a seamless digital coverage that integrates the best-known stratigraphy across the area. There was mention that the preliminary sheets may not have had suitable breakout of units such as the Arkansas novaculite (into upper, middle and lower members), Hot Springs sandstone broken out from the Stanley shale, as well as proper distribution of the Polk Creek Shale and Missouri Mountain shale.

Table 2 (at the end of this document) lists the source maps chosen for Hot Springs National Park, in addition to a unique "GMAP ID" number assigned to each map by GRE staff for data management purposes, map scale, and action items.

Also of interest, the U.S. Geological Survey Folio (215) from 1923 covers the area. This folio contains excellent descriptions of geologic units, features, and processes relevant to the map coverage. It would provide an important source of information for the GRE digital geologic mapping team and report author. The folio is also available at the following address: http://txspace.tamu.edu/handle/1969.1/3685

Purdue, A.H. and Miser, H.D., 1923, Hot Springs folio, Arkansas, USGS, Geologic Atlas of the United States Folio GF-215, 1:62,500 scale.

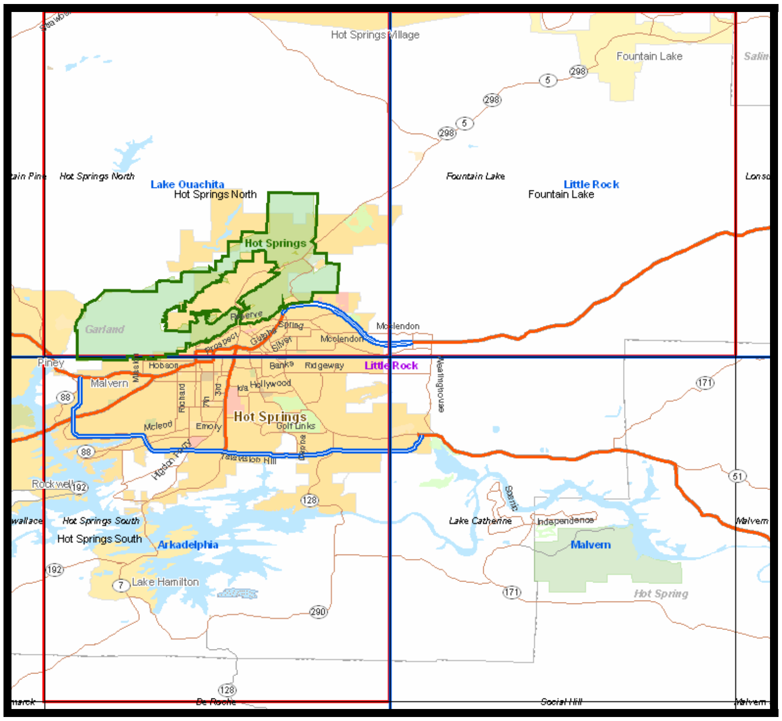

Figure 1. Maps of interest for Hot Springs National Park. The figure shows USGS 7.5' quadrangles (red outline), 30' × 60' sheet (blue outline, blue font labels), and 1° × 2° sheets (purple outline, purple font labels). The green outlines represent park boundaries. Note: the Lake Catherine quadrangle is an addition to the quadrangles of interest.

Additional items of interest pertaining to geologic mapping from the scoping

In order to avoid conflicts with surrounding landowners, the park would like to do thermal mapping to identify hotspots to superimpose with aerial photographs and the geology. The park has interest in detailed structural analysis including the orientations of folds, thrust faults, joints, and minor faults and fractures. Detailed outcrop mapping may help define the geothermal recharge area.

Geologic Resource Management Issues

The scoping session for Hot Springs National Park provided the opportunity to develop a list of geologic features and processes, which will be further explained in the final GRE report. During the meeting, participants prioritized the most significant issues as follows:

(1) Geothermal system
(2) Mass wasting
(3) Disturbed lands and surrounding development
(4) Surface water issues
(5) Paleontological resources

Geothermal System

The hot springs at the park are not geothermal in the classic sense. Instead of an anomalously elevated geothermal gradient (often to due to local igneous activity), the water at Hot Springs heats under a normal geothermal gradient. Isotope dating indicates the heated water at the surface is approximately 4,400 years old. Geologic structures (a faulted, eroded, plunging anticline) and bedding slowly conduct water deep beneath the surface in the recharge area. Then, due to the unique underlying geologic setting, this heated water is driven relatively quickly to the surface on the slopes of Hot Springs Mountain by hydraulic head. It retains much of its geothermal energy. Because hydraulic head drives the system, any changes to pressure or flow paths in the recharge area can rapidly affect discharge at the hot springs.

The hot springs are the primary natural resource at the park. As such, the water quantity and quality of the springs are of utmost concern for park resource management. The number and location of springs changes over time. There is some question as to how long the thermal activity will continue in the area before the vent seals itself. Discharge from the hot springs is relatively low, approximately 640,000 gallons per 24 hours. The park's goal is to restore and lease the historic bathhouses along Bathhouse Row. Precipitated minerals clog much of the original plumbing. There is some concern over whether total water quantity is sufficient to supply all future facilities. There is also concern of third party piracy of the park's geothermal resource. East of the park, a third party could sink a borehole down 910 m (3,000 ft) and tap into the park's resource. Drilling laws do not currently control wells in the recharge area.

The recharge area of the hot spring system is complex and poorly understood. Geologists have not delineated the exact extent of the recharge area which is generally north and east of the park. Recent blasting, some 9 km (5.5 miles) east of the park, for a highway expansion project and Crossgate Baptist Church complex caused a local, 15-year-old cold water well (Bratten well) to start discharging geothermal water at a maximum temperature of 34°C (93°F) on March 1, 2006. Until this time, this area was considered outside the recharge zone for the hot springs at the park. The connection between Bratten well and the hot springs within the park, if any, is not understood. It is also unknown how the blasting affected overall thermal flow or if this has any impact on the geothermal system at the park. The distance between the well and the park crosses three anticlines and several large thrust faults through sub-meter scale fractured rock. The Bratten well may serve as an analog to potential impacts on the hot springs geothermal system if development continues closer to park boundaries.

The highway developers did not include the park or the U.S. Geological Survey for comments on the initial environmental assessment. Developers have to build the highway either over the Arkansas Novaculite (expensive), or blast through it. Shockwaves from these blasts extend down into the fractured subsurface and may disturb the geothermal system. Since the Bratten well incident, construction activities are on suspension pending further research for the next three years. The U.S. Geological Survey started work in FY2007. Goals of this research are: 1) determine if the newly produced water in Bratten well is geothermally unique, 2) perform geophysical logging and water sampling from Bratten well and other important cold water sites, 3) produce a detailed water level map, 4) obtain Sr geochemical information, 5) research and define the recharge area for Hot Springs, 6) perform hydraulic monitoring to determine patterns in hydraulic head variations. The study wants to add continuous discharge monitoring at individual springs in the park. This would help define individual flow paths and the data on discharge could relate back to hydraulic head variations.

Abundant data exist on the geochemical characteristics of the hot springs. The park tests and monitors drinking water constantly. Some recent work by hydrologists with the U.S. Geological Survey focuses on dating spring water and comparing the geochemistry of geothermal waters at Hot Springs with regular well water. Radium from some carbonate tufa substrates have caused radon issues at some of the bathhouse structures in the park. Beneath park headquarters, in a dirt crawl space, radon concentrated to dangerous levels before the park installed an adequate ventilation system. Beneath the Hale Bathhouse, gamma radiation levels reached 3,500 microrad/hr. Radium precipitated against the older metal plumbing surfaces.

Mass Wasting

The steep slopes surrounding Hot Springs are extremely prone to landslides, rockfalls, and slumps. Tree roots and freezing water wedge the rocks on the cliffs apart. During early construction of the town of Hot Springs, developers dug into the hillsides at the toe of the slopes to create more stable, level ground to build on. Undercutting the slopes and exposing already unstable talus deposits created even more slope hazards below the near vertical cliffs in some areas. Slide events have buried cars, inundated the lower floors of local hotels, and even killed local residents. Landslides threaten park and town infrastructure. Remediation efforts include slathering the exposed rocks with concrete and building retaining walls. Spring discharge in these areas make rockfall prevention nearly impossible as seeping water dissolves concrete stabilizing structures. Some cliffs and slopes are anchored with high tensile nets and bolts. One such area contains a fractured tufa deposit above the park’s geothermal cooling towers, which cool the hot water to temperatures of ~39°C (101-102°F). Nets and bolts prevent the tufa from spalling off the slope and damaging park infrastructure.

Disturbed Lands and Surrounding Development

Humans have long been attracted to the Hot Springs area for its geologic resources. Prehistoric mines and quarries are evidence of early novaculite extraction. Indigenous people removed some 10,000 tons of material from some of these ancient quarries. Tools and other implements made from Arkansas Novaculite and chert are found hundreds of kilometers away. Chert from quarries in the Big Fork Chert formation supplied whetstones. North of the park are several abandoned aggregate quarries. The park now uses Grave’s pit, a former quarry for road material, as a storage area. The park is concerned about the possible development of further quarries for road building materials and adjacent housing tracts.

The Hot Springs area was prospected for oil and gas development in the 1920's. Several wells exist from this period, but all were abandoned.

Local, adjacent logging and clear-cutting for housing developments are of concern to park resource management at Hot Springs. Ridges are especially attractive potential homesites. Clearing vegetation changes the nature of the surficial cover type. Lack of vegetation may lead to increases in sediment load in the region's streams and rivers. This in turn may change channel morphology. Increases in impervious surfaces such as roads, parking lots, buildings, and driveways will in turn increase surficial runoff hastening erosion and channel incision. As mentioned earlier, any introduced contaminants or waste will take approximately 4,400 years to cycle through the hydrogeologic system. This presents serious concerns for long-term resource management. Residential planners are relying on a local highway project (described in above geothermal section) to increase local population and urban infrastructure through a forested area east of Hot Springs National Park. Park resource managers have not fully determined the impacts on park resources, including thermal water flow, of this planned development.

Surface Water Issues

In general, there are only short runs and streams on the surface of Hot Springs National Park. Hot Springs and Whittington Creek including the first-, second-, and third-order tributaries are almost entirely engineered underground through the town of Hot Springs. Fluvial issues at Hot Springs National Park include flooding of the buried Hot Springs Creek along the main street of Bathhouse Row. This is the primary drainage for the surrounding slopes and catastrophic floods have overwhelmed the engineered structures (a 5-m, 16-ft diameter masonry arch) and washed away vehicles on the streets above.

Lacustrine features in the park include two small, man-made lakes only two and eight acres in size. There is some sedimentation concern for these features, but it is not a resource management priority. They may be destroyed and restored.

Paleontological Resources

The Ordovician-age geologic units in the area contain some fossils including graptolites, conodonts, trilobites, brachiopods, and abundant plant fossils. In the Paleozoic, turbidity currents carried many of these now fossilized remains from nearshore to deeper water depositional environments. Some other geologic units in the area contain concretions which may or may not be associated with fossil remains. Fossils are not considered rare or especially valuable in the area, but the threat of theft is possible.

Features and Processes

The geothermal hot springs dominate the features showcased at the park. The springs on Hot Spring Mountain are controlled and locked in boxes. Early in the development of Hot Springs resort, engineers dug into the hillsides all the way to the bedrock around a given hot spring. Pea gravel was layered with perforated cast iron pipes to funnel water to larger catchments for distribution to the local bathhouse facilities and fountains. The NPS has installed various upgrades to this basic system including PVC pipes instead of cast iron which were prone to mineral precipitation. There are currently 26 point sources for the spring boxes. The water from the hot springs averages ~62°C

(~143°F), but the park tempers the water in cooling towers for use in the fountains and bathhouses. A 285,000-gallon concrete catchment tank sits behind the park headquarters building. A “display” spring cascades down a hillside along the Grand Promenade in the park. This feature intends to recreate a natural spring for visitor interest. Tufa deposits further upslope are evidence of previous spring discharge areas.

The pristine water quality of the hot springs in the park are world-renowned. Many local residents and visitors collect drinking water from the various spigots and fountains along Bathhouse Row. The park is unwilling to compromise on the volume or quality of water in the spring system.

Type sections refer to the originally described sequence of strata that constitute a geologic unit. It serves as an objective standard for comparison with spatially separated parts of that same unit. Preferably, a type section describes an exposure in an area of maximum unit thickness and completeness. There are excellent quality exposures of the Hot Springs Sandstone in the park. This unit contains clean quartz veins, and shelly layers with a high fracture permeability. Nearby at Cattle Gap (not inside the park), south of Norman, Arkansas is a classic section of the Arkansas Novaculite.

Recommendations

(1) Do age dating of tufa deposits in park area to determine a history of spring discharge.
(2) Seek to obtain funding (possibly from NSF) to do thermal mapping of the park area.
(3) Map landslide areas.
(4) Formalize type section locality for Hot Springs Sandstone.
(5) Park should locate geochemical studies done on Hg and other heavy metals in the area’s water, soils, and sediments.
(6) Perform detailed outcrop mapping to identify trends in local structures (fabric and joint patterns) and bedding that may define the geothermal recharge area.
(7) Incorporate historical land use evolution and delineation studies and the effects of geology on the park’s history into interpretive programs.
(8) Cooperate with local developers and other agencies to mitigate the effects of surrounding development on the park’s primary natural resource – geothermal water.
(9) Perform a comprehensive paleontological inventory of the national park. Establish a plan to deal with potential illegal sampling and collecting.

Action Items

(1) GRE report author needs to obtain the U.S. Geological Survey 1044-C report by Bedinger et al., in 1979.
(2) GRE will produce digital geologic map for the site (see above geologic mapping section).
(3) GRE report author needs to obtain graphics of recharge area in the ridges surrounding the park (Fountain Lake quadrangle).
(4) GRE report author needs to obtain the USGS folio for the area to find geologic unit textural descriptions as well as McFarland’s report on the stratigraphy of Arkansas.
(5) GRD will contact Vince Santucci (NPS-GWMP) regarding a possible paleontological inventory for the park.
(6) GRE report author needs to obtain AML report on Grave’s pit (used as a storage are) from Deanna Greco (GRD).

(7) GRE report author needs to obtain geochemical data focused on hot springs, as well as the Yates paper, and Bell and Hays paper (published soon) on the carbon isotope studies, age dates, and comparisons of spring to well waters in the area.
(8) Contact Larry Martin (NPS-WRD) regarding hydrologic studies in the area.

References

www.nps.gov/hosp (accessed May 3, 2007)

www.topozone.com (accessed May 3, 2007)

Table 1. Scoping Meeting Participants

Name	Affiliation	Position	Phone	E-Mail
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Table 2. GRE Mapping Plan for Hot Springs National Park

Covered Quadrangles	GMAP [1] ID	Reference	GRE appraisal	GRE Action	GRE file location	Scale
Hot Springs North	74672	B. R. Haley and C. G. Stone, 1994, Geologic Map of the Hot Springs North Quadrangle,, Arkansas, Arkansas Geological Commission, unpublished, scale 1:24,000	2007-0724: AGS proposing to revisit their field sheets to produce a better synthesized HOSP map to include Hot Springs North, Hot Springs South, Fountain Lake, and Lake Catherine 7.5's; GRE has received scans of all from AGC; . Needs map unit descriptions and correct citation information (date, series).	GRE will convert files when delivery received from ARGS	E:\gis-nps_by_gmap_id\74672_hot_springs_north_AR_7.5'	24000
Hot Springs South	74673	B. R. Haley and C.G. Stone, 1991, Geologic Map of the Hot Springs South Quadrangle,, Arkansas, Arkansas Geological Commission, unpublished, scale 1:24000			E:\gis-nps_by_gmap_id\74673_hot_springs_south_AR_7.5'	24000
Fountain Lake	74681	B. R. Haley and C.G. Stone, 2007, Geologic Map of the Fountain Lake 7.5' Quadrangle,, Arkansas, Arkansas Geological Commission, unpublished, scale 1:24,000			E:\gis-nps_by_gmap_id\74681_fountain_lake_AR_7.5'	24000
Lake Catherine	74769	unknown, 2007, Geologic Map of the Lake Catherine Quadrangle,, Arkansas, Arkansas Geological Commission, unpublished, 1:24000 scale			unobtained	24000

[1]GMAP numbers are unique identification codes used in the GRE database.